Journal of Coastal Research	9	3	698–701	Fort Lauderdale, Florida	Summer 1993

Storm Surge Deposits in North Sea Salt Marshes Dated by ^{134}Cs and ^{137}Cs Determination

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ABSTRACT

EHLERS, J.; NAGORNY, K.; SCHMIDT, P.; STIEVE, B., and ZIETLOW, K., 1993. Storm surge deposits in North Sea salt marshes dated by ^{134}Cs and ^{137}Cs determination. *Journal of Coastal Research*, 9(3), 698–701. Fort Lauderdale (Florida), ISSN 0749-0208.

At the margins of eroding salt marshes on the German North Sea coast, shell layers have been identified and interpreted as storm surge deposits. This interpretation is supported by cesium dating of the younger part of the sequence. The dates indicate an almost constant sedimentation rate over the last thirty-five years. Extrapolation of this rate to older storm surge deposits enables the identification of individual storm surge strata back to 1926.

ADDITIONAL INDEX WORDS: *Salt marsh erosion, shell layers, cesium dating, Sylt Island.*

INTRODUCTION

Major parts of the salt marshes along the Wadden Sea coast of the North Sea are subjected to modern erosion. The salt marsh cliffs on the Island of Sylt are about 80 cm high and retreat at a rate of about 30 cm·yr^{-1} (EHLERS, 1988b). Unlike the high cliffs of the dune coasts or the Plio-Pleistocene core of the island, the salt marsh cliffs are exposed to erosion during almost every ordinary tide, with peak rates being reached at spring tides or during storm surges (EHLERS, 1988a). The salt marsh cliffs expose rhythmic bedding. This stratification of salt marsh sediments is assumed to represent changes resulting from annual weather cycles (REDFIELD, 1972). However, in contrast to varves in lake sediments, the irregular salt marsh surface with its plant hummocks results in discontinuous, patchy deposition, so that it may be impossible to identify years during which strong winterly storms did not occur.

In contrast to observations at other salt marshes (BOUMA, 1963; REDFIELD, 1972; ALLEN, 1990), the lamination slightly thickens upward. This neither reflects an increase in the velocity of sea level rise nor compaction of the lower parts of the deposits, but rather the increase in sedimentation with the approach of the retreating cliff.

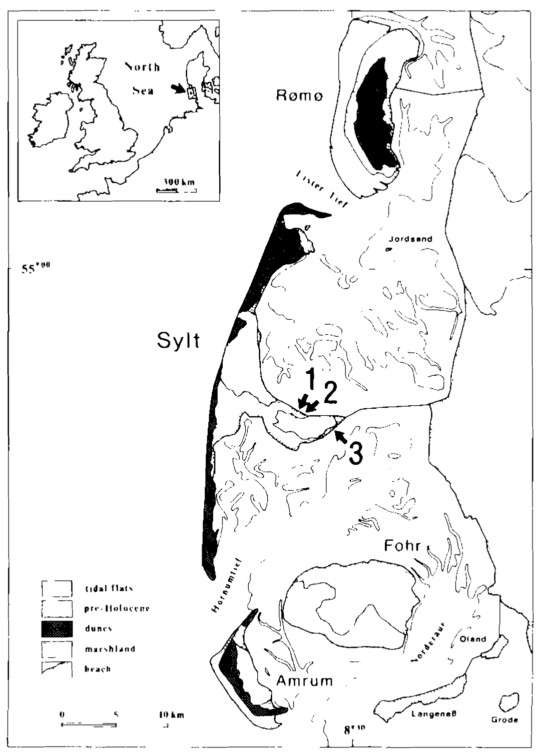

Figure 1. Location map.

92068 received 22 July 1992; accepted in revision 26 October 1992.

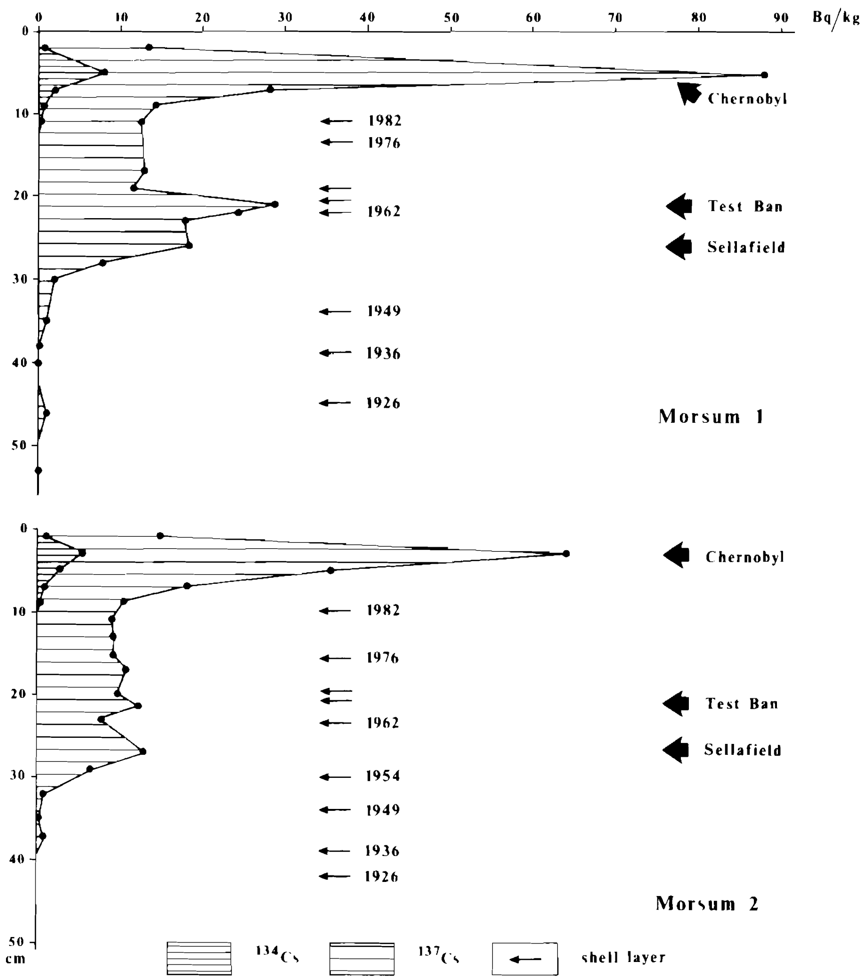

Figure 2. Depth profiles of ^{134}Cs and ^{137}Cs in two sections from the north coast of the Nösse Peninsula, Sylt; storm surge beds are indicated.

During strong storm events, overwash drives tongues of sand and intermixed shells inland onto the salt marshes where they later become covered by normal salt marsh accretion of silt and clay. Because the storm surges of recent centuries are well recorded, these shell-rich beds can be used as a tool for dating the salt marsh sedimentary sequence (STIEVE and EHLERS, 1993).

METHODS

In order to date the sequence the content of radioactive cesium has been used. The method has been described elsewhere (DELAUNE *et al.*, 1978, 1990; PATRICK *et al.*, 1990). However, all those studies were undertaken on pre-'Chernobyl event' sediments and were restricted to determination of ^{137}Cs deposited from fall-out of the nuclear bomb testing between 1955 and 1963. The Chernobyl accident of 1986 provided another datable horizon, the ^{137}Cs concentration of which far exceeds that of the fallout from earlier bomb testing in the sediments. In addition to ^{137}Cs, ^{134}Cs also occurs in the same sediment unit. ^{134}Cs characterises young fallout because of its short, 2.06 years, half life.

Three sections of the salt marsh cliff on the Isle

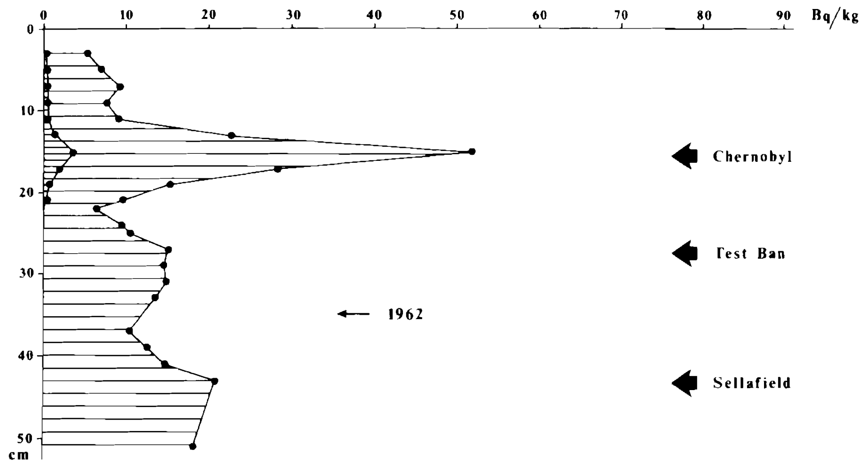

Figure 3. Depth profiles of ^{134}Cs and ^{137}Cs in a section from the south coast of the Nösse Peninsula, Sylt; the single storm surge layer is indicated.

of Sylt were studied; two on the north coast and one on the south coast of the Nösse Peninsula (Figure 1). Whereas the north-facing coast is exposed to storms from the northwest via the Lister Tief inlet, the south coast is in a rather protected position. However, both coasts are retreating. In both cases, the marsh sediments are well stratified. Numerous shell layers are present only in

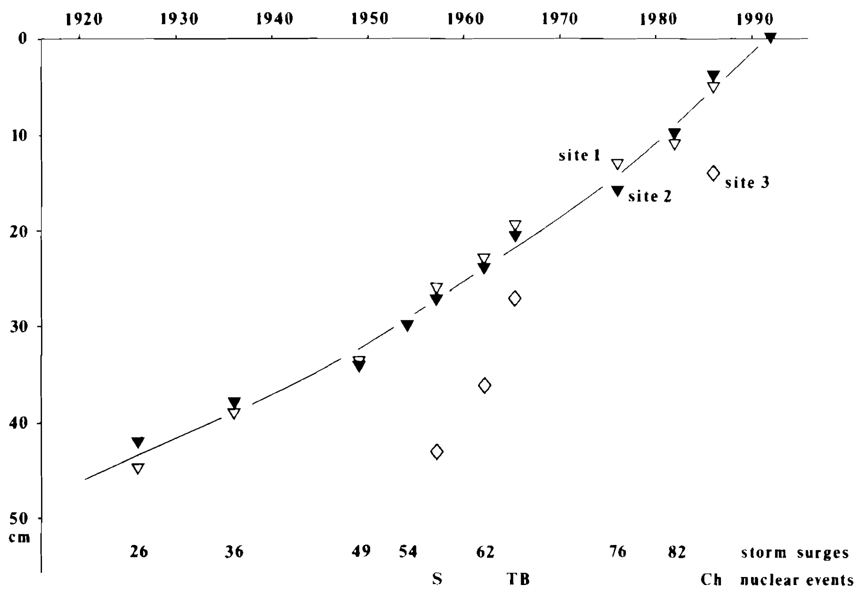

Figure 4. Storm surge layers and Caesium events plotted against depth.

the north coast sequences. In contrast, only one 2 cm thick sand layer could be identified in the south coast site.

RESULTS AND DISCUSSION

Three well-documented events can be identified at all three sites from the Cesium curves (Figures 2 and 3): the Chernobyl reactor accident (1986), the radioactive fallout peak from the bomb tests shortly before and after the Partial Test Ban Treaty of 1963 (1962–1966) and the Sellafield accident (1957). The Cesium distribution indicates that sedimentation has occurred at rather constant rates at all three sites. However, the sedimentation rate on the more protected south coast was higher than on the north coast. On the south coast (site 3), the Chernobyl horizon is found at a depth of 15 cm, whereas on the north coast in sites 1 and 2, it is situated just 4–5 cm below the present surface. The markedly lower position at site 3 is caused by burial under a beachridge-like feature. The sediment above the Chernobyl layer also shows some degree of contamination by both ^{137}Cs and ^{134}Cs, that arises from reworking of contaminated material. The vertical ^{134}Cs distribution also indicates that some down-profile migration of the radionuclides has taken place at all three sites, but to a rather limited extent.

The established dates of the radioactive contamination events allow the shell layers in the upper part of the profiles to be related with certainty to the well documented storm surges of recent decades (PETERSEN and ROHDE, 1977; FÜHRBÖTER, 1986). In Figure 4, sediment age has been plotted against depth. The dates from the north coast (sites 1 and 2) all fall on a smooth curve, that demonstrates a rather constant sedimentation rate of about 0.8–1.2 $cm \cdot yr^{-1}$. On the basis of dates for mean sea level from 14 German North Sea gauges during the period 1940–1975 (FÜHRBÖTER, 1986), a sea level rise of about 30 $cm \cdot century^{-1}$ can be expected. Salt marsh accretion at the test sites has outpaced sea level rise resulting in a general elevation of the salt marsh surface.

For the north coast sites, a cautious extrapolation beyond the reach of the Caesium contamination has been attempted. Below the 'Sellafield peak', three to four shell layers are visible. The shell beds representing the strong storm surges of 1949 and 1936 are easily identified (Figure 4). The lowest shell bed seems to represent the 1926 storm surge. There are no shell layers deeper in the sections. Assuming a relatively constant retreat rate of about 0.3 $m \cdot yr^{-1}$, the present coastline would still have been over 20 m inland before this time and, therefore, possibly situated inland of the zone of shell deposition during storm overwash.

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□ ZUSAMMENFASSUNG □

An den Abbruchkanten unbedeichter Salzmarschen auf Sylt lassen sich Muschellagen identifizieren, die als Sturmflutablagerungen gedeutet werden können. Diese Deutung wird gestützt durch Caesium-Datierung des jüngeren Teils der Schichtenfolge. Die Daten belegen eine nahezu konstante Sedimentationsrate für die letzten 35 Jahre. Durch Extrapolation lassen sich die Ablagerungen älterer Sturmfluten (bis 1926) identifizieren.